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Battery Packaging for Superior Thermal Performance

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Battery Packaging for Superior Thermal Performance

ABSTRACT

Heat build-up is a major design consideration in large battery modules such as those used in data centers. Excessive battery temperature can reduce the reliability of equipment in a data center and can pose safety problems. This disclosure describes techniques that encase the cells of the battery module in a potting medium, which can be a semi-rigid or liquid material of moderate-to-high thermal conductivity and low electrical conductivity. The encasing results in improved cooling, energy density, and safety.

KEYWORDS

- Battery packaging
- Thermal design
- Li-ion cells
- Data center
- Power back-up
- Potting material

BACKGROUND

Heat build-up is a major design consideration in large battery modules such as those used in data centers. Excessive battery temperature shortens battery life, prevents the full charging of the battery, and poses safety problems. High battery temperature can thus jeopardize the reliability of equipment in the data center. Thermal problems, and the need to conduct heat away from batteries, increase with data center power demand and battery capacity.

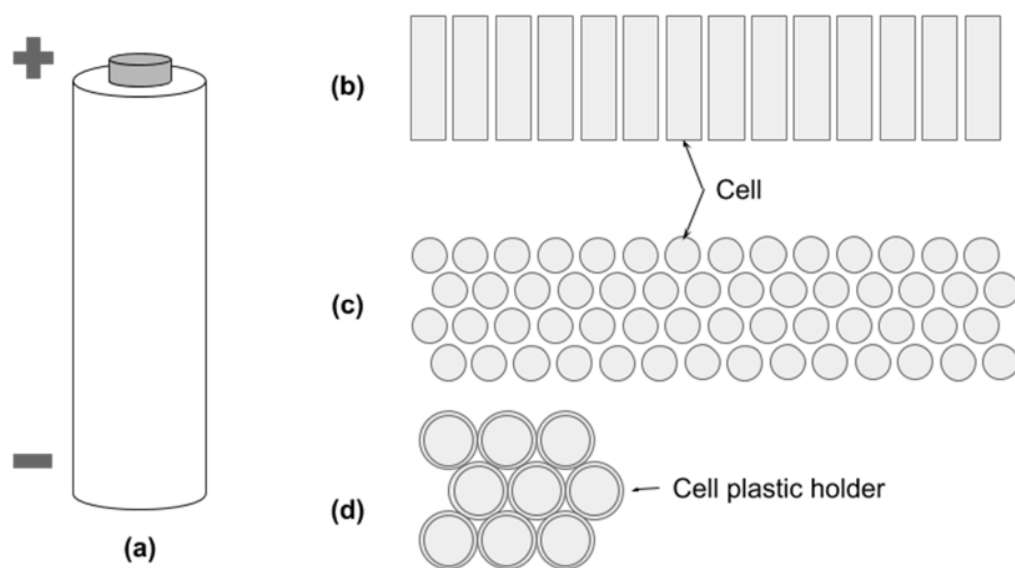


Fig. 1 (a) A Li-ion cell (b) Side view of a group of Li-ion cells connected to form a battery module (c) Top view of battery module (d) Detail of battery module

Large power backup battery modules, e.g., as used in data centers, typically comprise tens or hundreds of Li-ion cells connected in parallel and serial. As illustrated in Fig. 1(a), each constituent Li-ion cell is cylindrical, similar in form factor to a AA or AAA cell. A group of Li-ion cells forming a rectangular battery module are shown in side view in Fig. 1(b) and in top view in Fig. 1(c). As illustrated in Fig. 1(d), a constituent cell is encased in a plastic holder. The plastic casing serves to rigidly hold the cells together. A large copper sheet connects the cells together to conduct large charging or discharging currents. For safety, the whole module is covered by an insulating sheet.

Heat is typically carried away from the battery module by an internal fan. However, in power-dense battery modules, the airflow generated by the fan is too weak to sufficiently cool the battery. Also, air can only exit the battery module through a perforation that is by design kept small for safety reasons, e.g., to prevent the escape of flames in the event of an explosion.

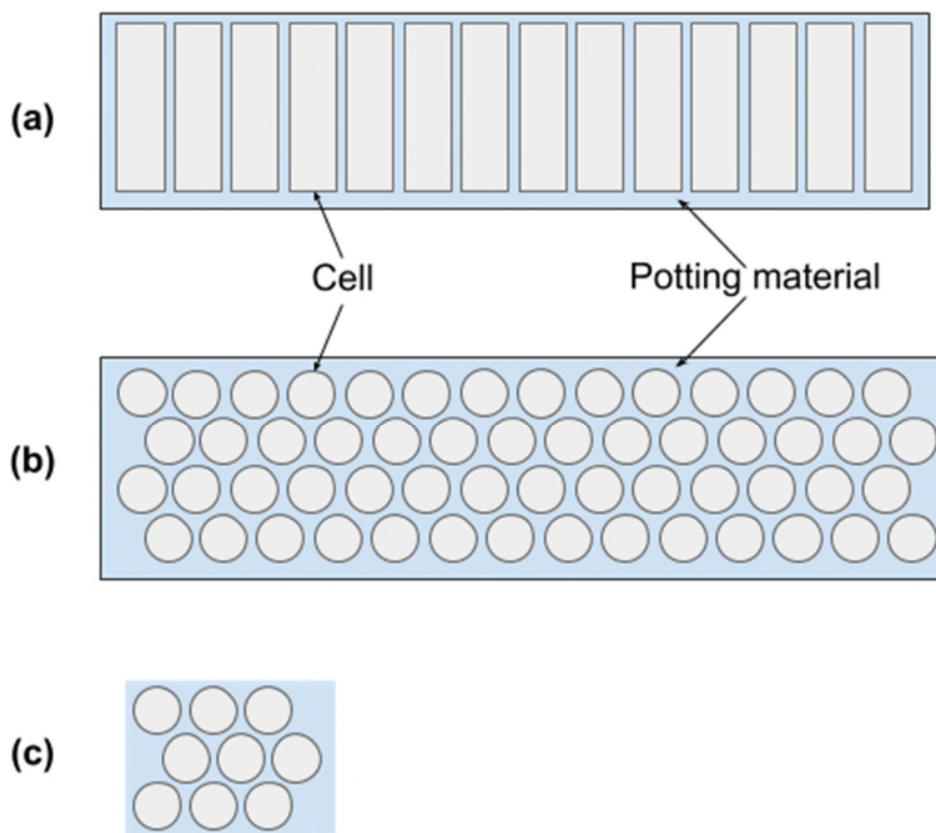
DESCRIPTION

Fig. 2 (a) Side view of a group of Li-ion cells immersed in a potting material (b) Top view of the battery module (c) Detail of the battery module

Per the techniques of this disclosure, as illustrated in Fig. 2, the cells of the battery module are encased in potting material (shown in blue). The potting material can be a semi-rigid or liquid material of moderate-to-high thermal conductivity and good dielectric characteristic. The cells comprising the battery module are placed inside a mold, or pot, which is filled with an electrically insulating and thermally conducting liquid that hardens, e.g., a thermosetting polymer, a silicone rubber gel, an epoxy resin, etc. The copper sheet that conducts large charging or discharging currents is also concealed within the potting material. As illustrated in Fig. 2(c), the use of potting material obviates the need for encasement of individual cells in plastic holders. Also obviated is the insulating sheet that covers the entire module.

Some advantages of the described techniques are as follows.

- **Improved cooling:** The pervasive presence of the potting material (or thermally conducting liquid) in the interstices between the cells and throughout the volume of the battery module improves thermal conductivity. The heat generated by the cells easily transfers to the surface of the battery module, where it is moved away by convection via the airflow of an internal fan. Heated air no longer exits through a small perforation; rather it skims the much larger surface area of the battery module.
- **Improved safety:** The cells being embedded in the potting material or thermally conducting liquid, flames emanating from a cell (in the event of malfunction) do not escape. Further, similar to the safety vent on the bottom of each cell, a flame escape path can be built into the potting to mitigate this issue.
- **Increased energy density:** The removal of the plastic encasement (or reduction of the inter-cell air-gap) allows for an increase of about 20-30% in usable volume. Cells can be packed more tightly, resulting in a higher energy density.
- **Improved handling safety:** The concealment within the potting material of the copper sheet (that conducts large (dis)charging currents) reduces the chance of short circuits during handling.

CONCLUSION

Heat build-up is a major design consideration in large battery modules such as those used in data centers. Excessive battery temperature can reduce the reliability of equipment in a data center and can pose safety problems. This disclosure describes techniques that encase the cells of the battery module in a potting medium, which can be a semi-rigid or liquid material of

moderate-to-high thermal conductivity and low electrical conductivity. The encasing results in improved cooling, energy density, and safety.